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Helminthic Infections in a Tsunami-Affected Area: Soil Contamination and Infection Rates in the Population

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Abstract

In February 2005, soil samples from non-tsunami and tsunami-affected areas in Phang-nga Province were examined for helminth objects. The result showed a higher detection rate in the affected area (15.5%) than the non-affected area (6.7%). In Ban Nam Khem, a mangrove swamp near the shelter of some fishermen who refused to move to the Rescue Centers after the tsunami disaster was highly contaminated with human feces. The detection rate of *Ascaris lumbricoides* and *Trichuris trichiura* eggs in soil was 41.2%. When we repeated the examinations in January and May 2006, the rates had increased to 100 and 60.0%, respectively. The stools of schoolchildren and inhabitants in the high-risk area were examined by Katz's modified thick smear technique. The prevalence of soil-transmitted helminths in the population was 34.9%. This was lower than the previous study in March 2004, before the tsunami, when the prevalence was 42.2%; however, there was no statistically significant difference between the two observations. Since it is difficult to change the habit of defecating outside latrines, all infected persons, including inhabitants with a habit of indiscriminate fecal disposal, and all schoolchildren, were treated to eradicate the source of helminthic infection. Health education was given to the community.

The study showed that the tsunami had a minimal effect on the helminthic infection rate in the population. It had a great effect on the environment, since it cleaned up soil polluted with human excreta. However, infected persons passed feces into the environment, and the accumulation of helminth eggs began again.

Keywords: Tsunami disaster, helminth eggs, soil contamination, infection rate, Thailand

Introduction

On December 26, 2004, a massive earthquake with a magnitude of 9.3 shook the Indian Ocean floor 150 miles off the coast of Sumatra, resulting in a colossal tsunami or tidal wave, which ripped through South Asia. Thailand was among the nations hit by the tsunami, with 5,395 of deaths, 3,132 persons missing, and 8,457 injured. In addition, 400 Thai fishing villages were destroyed, ruining the livelihoods of thousands of people living in the south and west of Thailand [1]. In the south, Ban Nam Khem, in Takua Pa District, Phang-nga Province, was one of the villages destroyed by the tsunami. All of the houses built close to the sea collapsed, and survivors stayed around the destroyed structures for about 1 month before moving to Tsunami Rescue Center(s). At that time, there were many serious problems, such as food, drinking water, health, habitat and lack of facilities (latrines, electricity, and clothing). It

may be assumed that people had to defecate on the ground. From the parasitological perspective, this could lead to the widespread distribution of helminthic infections in the future, especially soil-transmitted helminthes (STH).

Ascariasis, trichuriasis, and hookworm infections are caused by STH that are widely distributed in tropical and subtropical regions of Asia, Africa, and America [2]. STH occur in all parts of Thailand, but are more prevalent in the south, where moisture is adequate throughout the year [3]. The distribution and transmission of STH are related to low socio-economic status, poor environmental sanitation, and poor personal hygiene and habits [4]. Muennoo *et al* [5] reported that in the group of fishermen 72.8% had STH infection. School-age children are an important high-risk group for STH, because they are continually exposed to contaminated soil and water, but probably lack awareness of the need for good personal hygiene [6].

STH utilize the soil as an intermediary vehicle for transmission to the human host. Eggs of *Ascaris*, hookworm and *Trichuris* in soil must be capable of survival from the single-cell to the embryonated stage, which is capable of infecting humans. Live infective stages of STH were detected from the environment in endemic areas by flotation method [7,8]. *Ascaris lumbricoides* eggs are an indicator for soil contamination with human feces [9].

This study was undertaken to detect the contamination of helminth eggs in soil samples from non-tsunami and tsunami-affected areas, to examine the prevalence of STH in the population, and to investigate behavioral risk factors that may influence the transmission of helminthic diseases. An understanding of the helminth situation in the community, would elucidate the effects of the tsunami on STH infections in the tsunami-affected areas.

The Ethics Committee of the Faculty of Tropical Medicine provided ethical clearance for this study protocol, Approval Number: MUTM 2006-054.

Materials and methods

Environmental observation and soil collection

Fifty days post-tsunami, environmental fecal contamination was surveyed in Amphoe Takua Pa, Phang-nga Province. Soil samples were collected from many places in non-tsunami and tsunami areas, *ie*, Ban Phrutiew, Ban Bangmuang, Ban Nam Khem, Ban Laem Pakarang, Ban Khukkhak, Ban Bangnieng, and Khao Lak Lamru National Park. The soil samples were examined in the laboratory of the Faculty of Tropical Medicine, Mahidol University, in Bangkok.

Study area

The results showed that the soil samples collected from Ban Nam Khem were heavily contaminated with helminth eggs, and therefore the study focused on this area. Ban Nam Khem inhabited a population of 3,499, with 966 households; most were fishermen residing close to the sea. When the tsunami hit, salt water intruded and covered the area, and their houses were destroyed. The survivors, all children and women, moved to Rescue Centers located in many parts of the district, but some fishermen refused to stay in the centers. They spent their time in shelters near the sea repairing their damaged fish-traps. We found that soil in the mangrove swamp near the shelters was contaminated with human feces; therefore, the study focused on inhabitants around polluted areas in Soi Taksin, Soi Suphan, and Soi Kopad. About 550 inhabitants were at high risk of infection.

The only school in the village, Ban Nam Khem School, had about 515 schoolchildren, 111 of pre-school/kindergarten age, 281 in grade 1-6, and 123 in junior high-school.

Soil examination

Surface soil samples in selected areas, such as the playground, near septic tanks of latrines, under bushes close to houses or other places with human excreta were collected for examination. The samples were kept in individual plastic bags and examined by sugar flotation method [10].

Soil collection and environmental observation were conducted in February and July, 2005, and in January and May, 2006.

Stool examination

Stool samples were collected from schoolchildren and villagers of all age groups

and examined by Katz's modified thick smear technique and cultivation method to determine the prevalence and intensity of worm infection. This was done twice, once in May 2006 and again in February 2007.

KAP on helminthic infections

Interviews using a questionnaire gathered information on knowledge, attitudes and practices in relation to helminthic infections among the population. At school, all students of grade 3 level and above were asked to answer the questionnaire in class. In the village, it was done at the same time as distribution of stool containers; most of the subjects were housewives who stayed home during the daytime.

Health education

Health education sessions on topics such as helminth infection, mode of transmission, prevention of diseases and environmental sanitation, were given after stool examination. To disseminate this information to schoolchildren, a staff-student meeting was held at the school to provide health education with demonstrations of worms from the infected students; posters and leaflets were given to the school, and the session ended with singing the "parasite prevention" song. In the village, group discussions and health education were undertaken concurrently with drug administration. Uninfected persons were included in the discussion.

Treatment

STH-positive villagers were treated with a single dose of 400 mg albendazole. The same dose of albendazole was given to all schoolchildren at the school to eradicate worm infestation.

Results

Soil examination

In the first visit, 88 soil samples were collected and examined for *A. lumbricoides* eggs. Two of 30 (6.7%) samples from the tsunami non-affected area contained *A. lumbricoides* eggs. In the tsunami-affected area, the detection rate was 15.5%. The results showed that 9/30 (30.0%) samples from Ban Nam Khem had *A. lumbricoides* and *T. trichiura* eggs (Table 1). In a certain place at Soi Taksin, 7/17 (41.2%) samples collected from a swamp area in the community contained *A. lumbricoides* and *T. trichiura* eggs. It is possible that the contamination occurred after the tsunami, since most of the eggs were alive.

When we visited the area in July 2005, it was high tide. Human excreta were in the seawater and some were floating on the surface. During our visit in January 2006, we collected 7 stool samples, found in the defecation area, for examination. Every sample contained helminth eggs (100% positive rate) as shown in Table 3, and soil around the fecal lumps showed 100% positive. Twenty soil samples were collected for re-examination in May 2006. A high detection rate (60%) was noted, since eggs continuously accumulated into the environment. The results of soil examination are shown in Table 2.

In the defecation area, hundreds of domestic flies were seen feeding on fresh excreta and resting on plants nearby.

Unfortunately, detection of helminth eggs in soil had not been conducted pre-tsunami.

Stool examination

The numbers of STH-infected persons by Katz's modified thick smear and cultivation method are summarized in Table 4.

Total positive persons were 99/283 and the prevalence of STH infection was 34.9%. They were infected with any one or with mixed infections with soil-transmitted helminths. *Trichuris* infection was the most prevalent in both groups. Strongyloidiasis persisted in the school-aged group, with an infection rate of 1.5%. Most cases had light infections, and the rates of moderate and heavy ascariasis and trichuriasis infections were 15.2 and 9.1%, respectively. No heavy hookworm infection was found, with only one moderately infected person seen.

A stool survey of the villagers in this area had been conducted in March, 2004 and comparative prevalence is shown in Table 5. There was no statistically significant difference between the two observations (χ^2= 1.65; $p \geq 0.05$).

Each positive case was treated with an effective dose of albendazole to eradicate worms

Table 1 Detection rate of helminth eggs in soil samples from Takua Pa District, Phang-nga Province, February 2005.

Area	No. of sample	Positive (%)	Helminth egg (eggs/gm; stages)
Non-tsunami			
1. Phrutiew Rescue Center	3	1 (33.3)	*A. lumbricoides* (2; embryonated eggs)
2. Bangmuang Rescue Center	7	0	
3. Soil Suphan	5	0	
4. Ban Pakweep School	3	1 (33.3)	*A. **lumbricoides*** (1; unfertilized egg)
5. Ban Bangkaya	1	0	
6. Ban Khukkhak	2	0	
7. Ban Bangnieng	7	0	
8. Khao Lak Lamru	2	0	
Total	30	2 (6.7)	
Tsunami-affected			
1. Ban Nam Khem			
1.1 Soi Taksin	17	7 (41.2)	*A. lumbricoides* (61; dividing cell, larva formation, embryonated eggs, dead larva, degenerated eggs) *T. trichiura* (3; dividing cell)
1.2 Soi Nakhon Si Thammarat	2	0	
1.3 Soi Suphan	2	0	
1.4 Health Center	1	0	
1.5 Ban Nam Khem School	1	1 (100)	*A.**lumbricoides*** (1; larva formation)
1.6 under big tree near the pond	3	1 (33.3)	*A.**lumbricoides*** (1; dead larva)
1.7 near the sea	4	0	
2. Ban Laem Pakarang	8	0	
3. Ban Khukkhak	5	0	
4. Ban Bangnieng	10	0	
5. Khao Lak Lumru	5	0	
Total	58	9 (15.5)	

Table 2 Detection rate of helminth eggs in contaminated soil collected from a mangrove swamp with human excreta in Ban Nam Khem Village, Takua Pa District, Phang-nga Province (February-May, 2006).

Time	No. of samples	Positive sample	Detection rate	Helminth eggs found
February, 2005	17	7	41.2	*A.l* and *T.t*
July, 2005	ND	-	-	-
January, 2006	7	7	100.0	*A.l* and *T.t*
May, 2006	20	12	60.0	*A.l* and *T.t*

ND = not done; *A.l - Ascaris lumbricoides*; *T.t - Trichuris trichiura*

from the body. Every person with a habit of indiscriminate fecal disposal was also treated.

Health education at the school and in the community was successfully conducted. Parents and teachers had increased health awareness, which was applicable to caring for their children. After discussing the problems of helminth infections with teachers, they understood the harmful effects and promised to repeat health education on suitable occasions.

Environmental observation

This was done at the same time as we distributed and collected stool containers in the village. Our findings were:

1. At present, the inhabitants of the area near the mangrove swamp is the Morgan group, who are fishermen from other seriously tsunami-affected areas in the district. The semi-permanent wooden houses had earthen floors and no latrines. Normally, they defecated in the swamp area, especially the males. Females used public toilets or the toilets of their neighbors during daytime. Babies and many small children defecated in the house' yards.

2. Few of the villagers had a habit of defecating outside latrines. They always used the swamp area when nature called, even though they had toilet facilities at home.

3. The children's excretory behaviors elsewhere was ignored by the parents, because they could not force them to use latrines.

Analysis of the questionnaires

Questionnaires were obtained from 153 schoolchildren and 79 villagers in the 3 study sites. The ages of the students ranged between 9-18 years, and in the latter group 18 to >60

Table 3 Helminth eggs in stool samples collected in the mangrove swamp in January 2006.

Sample	Helminth eggs per smear			Remarks
	Ascaris	*Trichuris*	Hookworm	Infected cases
1	0	100	1	1
2	106*	5	0	2
3	14*	62	2	3
4	5*	83	3	3
5	24*	58	14	3
6	36*	294	4	3
7	506	120	37	4

* unfertilized eggs
Remarks: stool examination results indicated that at least 4 infected persons were defecating in this area.

Table 4 Number of STH-infected persons in Ban Nam Khem Village, May 2006.

Area	Number of		Helminth infection (%)			
	Collected samples	Positive STH (%)	*A.l*	*T.t*	Hw	*S.s*
School	133	37 (27.8)	17 (12.8)	30 (22.6)	8 (6.0)	2 (1.5)
Village	150	62 (41.3)	21 (14.0)	48 (32.0)	23 (15.3)	0 (0)
Total	283	99 (34.9)	38 (13.4)	78 (27.6)	31 (11.0)	2 (0.7)

A.l - Ascaris lumbricoides; *T.t - Trichuris trichiura*; *S.s - Strongyloides stercoralis*; Hw - hookworm

years. Analysis showed that 18.1% had a habit of defecating outside latrines, with the adult group (29.1%) more than the school-aged group (12.4%). The area for defecation was in the grove of trees. Most of them had poor personal hygiene habits, since 62.9% walked barefoot outside the house, and 78.4% handled food with dirty hands. Although they stayed in a place considered endemic for STH infection, they did not clean fresh vegetables properly before consumption. The habit of indiscriminate fecal disposal, poor personal hygiene, and poor environmental sanitation, provided suitable conditions for the transmission of helminthic infections in the population.

Discussion

We took the opportunity, when the tsunami hit southern Thailand, to study helminthic infections in a tsunami-affected area. The results showed that the prevalence of STH infection pre- and post-tsunami was not significantly different, although it was slightly higher (42.2%) in the study done in March 2004. In a recent study, the results of soil examination showed high contamination (41.2-100%), but the infection rate in the population was 34.9%. It is possible that pre-tsunami, the soil was highly contaminated with helminth eggs, which were washed away by thousands of tons of seawater. Thus, the eggs detected from the soil in February 2005 were new batches releasing into the environment, since they were alive with various stages of development inside, and only one egg appeared with a dead larva.

Infective stage STH are killed by seawater. Most *Ascaris* eggs (97%) died after 2 days and *Trichuris* eggs swell rapidly and do not survive long in seawater. Hookworm eggs can survive for 5 hours. Larvae have low resistance to seawater and die within a short time [11]. During a high tide, the eggs and larvae in seawater are destroyed, and only excreta above seawater survive to maintain transmission to humans.

In conclusion, the tsunami had no effect on helminthic infections in the population. It had a great effect on the environment, since it cleaned up soil polluted with human excreta; thence, the infective stages of worms were washed away. But after that, infected person(s) passed feces into the

Table 5 Prevalence of soil-transmitted helminthes in the villagers of Ban Nam Khem pre- and post-tsunami.

Year	No. exam	No. positive	Prevalence	Helminth infection rate			
				A.l	*T.t*	Hw	*S.s*
March, 2004	102	43	42.2	17.6	33.3	10.8	0
May, 2006	283	99	34.9	13.4	27.6	11.0	0.7

Table 6 Risk behaviors in relation to transmission of helminthic infections of the population in Ban Nam Khem Village.

Factor / Behaviors	Frequency (%)		
	Schoolchildren	Villagers	Total
- have no latrine at home	3 (2.0)	12 (15.2)	15 (6.5)
- defecate outside latrine	19 (12.4)	23 (29.1)	42 (18.1)
- defecate in the groove	2 (1.3)	19 (24.1)	21 (9.1)
- wear shoes sometimes	81 (52.9)	65 (82.2)	146 (62.9)
- handle food with dirty hands	115 (75.1)	67 (84.8)	182 (78.4)
- improperly wash raw vegetables before eating	15 (10.1)	32 (40.5)	47 (20.3)

environment, and the accumulation of helminth eggs began again. Once the eggs are released into the surroundings, contamination persists for years. *Ascaris* and *Trichuris* eggs can survive more than one year in suitable conditions such as under soil in shaded areas and beneath the soil surface [12].

In our study, all schoolchildren, who are the high-risk group for infection, were treated. We realized that it is difficult to change the habit of defecating outside latrines, so treatment was provided to all infected persons and inhabitants with a habit of indiscriminate fecal disposal, to eradicate the source of helminthic infection.

In February 2007, stool examinations and helminth egg detection in soil will be repeated. We expect a decreasing prevalence of helminthic infections in the population, and a low rate of detected eggs in the environment.

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